UNIVERSITY II SERIES

MODEL 146 GENERAL PURPOSE SCALER

OPERATING AND INSTRUCTION MANUAL

BAIRD ATOMIC

CAMBRIDGE, MASSACHUSETTS

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BAIRD-ATOMIC INC.
7625 E. ROSECRANS AVE.
PARAMOUNT, CALIF. 90723
(213) 636-2556
SER. MAN. JERRY PERIGEN

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CONTENTS

		Page
1.	GENERAL DESCRIPTION	3
	General Purpose Scaler Definition	3
	General Purpose Scaler Specifications	5
2.	OPERATION	9
	Installation	9
	Grounding Considerations	10
	Controls, Indicators and Connectors	10
	General Operating Procedures	19
	Scaler-Timer	19
	Amplifier-Discriminator	21
	50 cps Operation Option and/or 22 Volt	22
3.	GENERAL PURPOSE SCALER THEORY	23
	General	23
	High Voltage Supply	23
	Amplifier	30
	Discriminator	34
	Scaler-Timer	35
	100 kc Decade Counter	36
	1 mc Decade Counter	40
	Timer	40
	Scaler Control	41

Page

Register 45
System Supply 46

4. TROUBLESHOOTING 47

5. PARTS LIST 51

APPENDIX 57
Model 146 General Purpose Scaler Schematic Drawings 57

Model 146 General Purpose Scaler

Operating and Instruction Manual

MODEL 146 GENERAL PURPOSE SCALER

Figure 1.1

CHAPTER
1

GENERAL DESCRIPTION

General Purpose Scaler Definition

The Model 146 General Purpose Scaler is a flexible instrument designed for general laboratory use. The wide range of high voltage, extending to 6000 volts, coupled with the variable discriminator and maximum amplifier gain of 1000, give the general purpose scaler its great versatility and permit its use in nearly every known nuclear counting application.

Three solid-state electronic decades provide the general purpose scaler a 1 microsecond pulse pair resolving time; an electromechanical register extends the total count capability to a maximum of 10 million counts.

GENERAL DESCRIPTION

The instrument features eight preset count positions and an electromechanical timer capable of being used in either the interval or preset time mode. A solid-state amplifier discriminator section yields three gain positions of 1000, 100 and 10 with 0-100% variable discriminator control.

The high voltage power supply, a solid-state DC-to-DC converter, employs a high-gain feedback amplifier to control the desired output level and to provide good regulation. The low voltage power supply is a separate module mounted on the rear apron of the main instrument chassis with four screws and is removable for servicing.

A compact steel cabinet houses the chassis assembly which is constructed in modular fashion to simplify troubleshooting and maintenance. The front panel, not including the timer panel, has a hinged front panel which opens for easy access to all the printed circuit cards. A wire stand positioned at the bottom of the cabinet allows inclined operation for control and viewing ease when used on a bench.

All printed circuit cards are built on 5" x 9" glass epoxy boards, guided and held in position by means of two plastic strips. Extender boards are available for servicing the unit during operation.

All controls are mounted on either the upper or lower front panel except the discriminator adjust potentiometer, mounted on the rear panel. All connectors are located on the rear panel. A variety of input modes is made possible by the use of a preamplifier connector

and individual voltage and current input jacks.

General Purpose Scaler Specifications

The published general purpose scaler specifications are fully as important as the instrument described, for the data provides a description necessary to correctly use the Model 146. Since Baird Atomic products benefit from a program of continuing evaluation and improvement, specifications are subject to modification.

General

Resolution	1 usec pulse pairs
Count Capacity	9,999,999
Electromechanical Register	Four digits (thousands count)
Electronic Decades	Three decades
Preset Counts	50, 100, 500, 1K, 5K, 10K, 50K, 100K

High Voltage Power Supply

Range	600 to 6000 volts DC
Current	1 ma
Polarity	Positive
Line Regulation	0.1% maximum from 105 volts AC to 125 volts AC
Stability	0.3% per day 0.05% per hour
Noise and Ripple	125 mv rms
Output Impedance	150K ohms

GENERAL DESCRIPTION

Amplifier-Discriminator

Input Modes	Current or voltage
Gain-Voltage	X 1000
Gain-Current	10 volts per microampere
Input Impedance	Voltage 10K ohms Current 50 to 100 ohms
Polarity	Negative
Rise Time	0.25 usec
Linearity	0.1%
Noise	0.2 mv peak-to-peak referred to voltage input 0.02 ua peak-to-peak referred to current input
Overload Recovery	10 usec for 100 x pulse
Gain Control	X 10, x 100, X 1000

Timer

Type	Liebel Flarsheim
Preset Time	1 second to 60 minutes
Calibration	Minutes and seconds
Elapsed Time Indicator	60 minute range
Accuracy	0.1 second

Connectors

Current Input	HN
HV Output	HN
Anticoincidence Input	BNC

Connectors (Cont.)	
Signal Input	BNC
Preamplifier	Amphenol 3102A-16S-1S
AC Power	115 volts AC 60 cps at 850 ma (220 volts 50 cps optional)
Dimensions	17-1/2" wide x 7" high x 15" deep
Weight	Approximately 40 pounds

CHAPTER
2

OPERATION

Installation

No special precautions other than those normal with commercial type laboratory equipment need be taken. The line cord should be plugged into a 3-wire system (third wire equipment ground) to keep the chassis at the same potential as other equipment.

If the general purpose scaler is used on a bench, nothing that would tend to block air circulation should be placed on top. Four rubber feet are provided to allow air to enter the ventilated bottom of the cabinet and exit through the top. When used with a shelf for rack mounting application, take care not to exceed the maximum operating temperature specified.

Grounding Considerations

The general purpose scaler, a very sensitive measuring device, is capable of analyzing high speed signals in the millivolt and microampere region. Accordingly, the internal grounding has been designed to avoid harmful ground loops and sensitivity to noise pickup.

To maintain the low sensitivity of the unit to spurious-counts when using other than Baird Atomic detectors, it is necessary to keep the detectors or probes completely protected from all kinds of electrical disturbances. Signals should be carried from the detector to the applicable input connector by coaxial cables with outer shield braid firmly grounded at both ends. The detector itself should be protected by a metal shield.

If care is not taken to prevent unwanted ground loops between the equipment ground and the power system, a significant increase in input noise can be expected when using preamplifiers not deriving power from the general purpose scaler.

Controls, Indicators and Connectors

All general purpose scaler controls and indicators, with the exception of the DISC. ADJ control, are located on the front panel as shown in Figure 2.1. The controls are functionally separated: all mode switches are mounted on the lower switch panel and all operating controls on the hinged main front panel. Chart 1 relates the controls and indicators to Figure 2.1 while describing

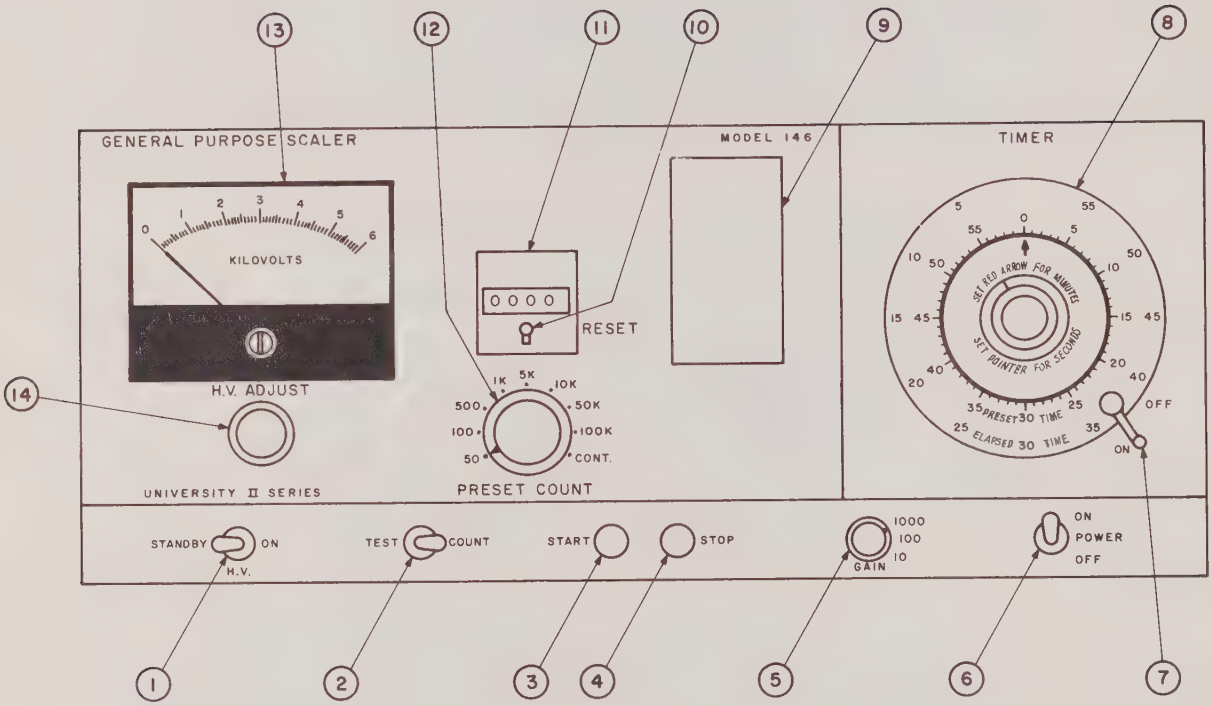
each control and indicator by function.

All connectors for connecting input source, and fuses for the line and high voltage including the control mentioned above are mounted on the rear panels. Figure 2.2 shows the fuses, connectors and DISC. ADJ control; Chart 2 complements the figure.

FRONT PANEL CONTROLS AND INDICATORS

Chart 1

REF. NO.	CONTROL or INDICATOR	FUNCTION
(1)	STANDBY-ON	a) ON - high voltage is connected to output connectors b) STANDBY - disconnects low voltage from transformer primary tap; secondary is still connected to output connector
(2)	TEST-COUNT	TEST applies internal clock signal to the scaler; it is otherwise gated off and replaced by the signal from the amplifier output terminal



FRONT PANEL CONTROLS AND INDICATORS

Figure 2.1

FRONT PANEL CONTROLS AND INDICATORS

Chart 1 (Cont.)

REF. NO.	CONTROL or INDICATOR	FUNCTION
(3)	START	Resets scaler and enables scaler gate when operated; also initiates timer operation if ON-OFF timer switch is set to ON
(4)	STOP	Stops scaler and timer when operated
(5)	GAIN	Selects amplifier gains of 1000, 100 or 10 with 3-position switch
(6)	ON-POWER-OFF	Connects power supply to line
(7)	ON-OFF (Timer)	Readies timer for operation in ON; stops scaler upon reaching preset time and being tripped to OFF

FRONT PANEL CONTROLS AND INDICATORS
Chart 1 (Cont.)

REF. NO.	CONTROL or INDICATOR	FUNCTION
(8)	TIMER	Electromechanical timer operates in either interval or preset time mode
9	Electronic Decades	Indicates total count for preset count positions 50, 100, 500, 1K, 10K, 100K and CONT., and acts as register multiplier for preset count positions of 5K, 10K, 50K and 100K; least significant digit is to right
(10)	RESET	Mechanical reset for register only
(11)	Register	Four-digit electromechanical counter follows the electronic decades

FRONT PANEL CONTROLS AND INDICATORS

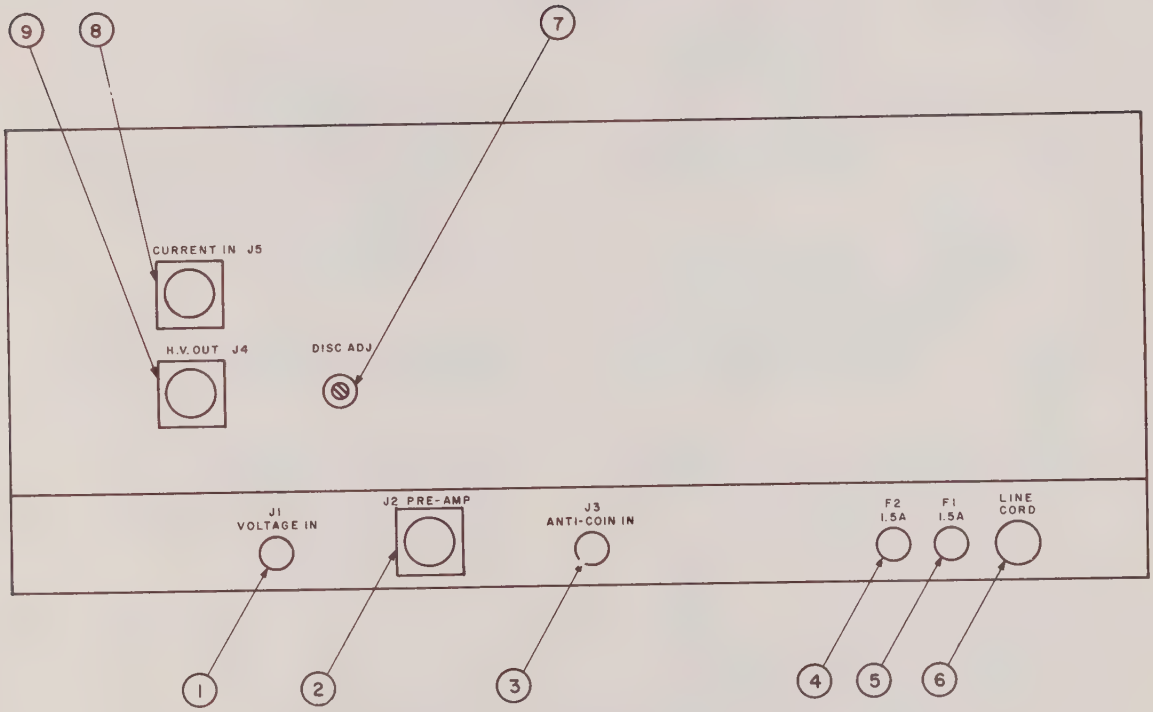
Chart 1 (Cont.)

REF. NO.	CONTROL or INDICATOR	FUNCTION
(12)	PRESET COUNT	Selects the various multiplier outputs from the decades to feed into the register
(13)	High Voltage Meter	Indicates high voltage reading
(14)	H. V. ADJUST	Adjusts high voltage level from zero to 6 KV with 10-turn potentiometer

REAR PANEL FUSES AND CONNECTORS

Chart 2

REF. NO.	FUSE or CONNECTOR	FUNCTION
(1)	J1 VOLTAGE IN	AC coupled to high impedance voltage input of amplifier; parallels preamplifier signal input



REAR PANEL FUSES AND CONNECTORS

Figure 2. 2

REAR PANEL FUSES AND CONNECTORS

Chart 2 (Cont.)

REF. NO.	FUSE or CONNECTOR	FUNCTION
2	J2 PRE-AMP	AC coupled to high impedance voltage input of amplifier; contains + and -18 volts DC at 10 ma to supply the preamplifier; may be connected to any standard transistorized Baird Atomic probe or counter
3	J3 ANTI-COIN IN	Connects to discriminator output gate; may be used in the coincidence or anticoincidence mode depending on switching levels; gate is enabled when -15 volts negative or no signal level exists; gate is disabled when at ground or positive level
4	F2 1.5 A	Fuses -18 volt supply to series regulator that drives high voltage transformer primary center tap

REAR PANEL FUSES AND CONNECTORS
Chart 2 (Cont.)

REF. NO.	FUSE or CONNECTOR	FUNCTION
(5)	F1 1.5 A	Primary line fuse
(6)	LINE CORD (System Supply)	Connects to power outlet; normally 115 volts AC, 60 cps, the third wire tied to equipment ground
(7)	DISC. ADJ	Controls discrimination level from 0-100% of full scale input (10 volts) from amplifier
(8)	CURRENT IN J5	AC coupled to low impedance current input of amplifier; may be connected directly to detector
(9)	H.V. OUT J4	Connects to source of high voltage; maximum output voltage is greater than 6KV

General Operating Procedures

The Model 146 General Purpose Scaler is a versatile instrument with several possible operating modes. These operating procedures are intended as a guide only to assist the operator in initial setup. To facilitate understanding, discussion centers on the several general purpose scaler sections.

Scaler-Timer

The scaler consists of two counting segments: a three decade electronic, solid-state counter and a four-digit electromechanical register with a periodical switch closure on the count of 100. It is thus possible to select several preset count options by using the electronic section as a multiplier. When the preset count switch is set on positions 50, 100, 500 or 1K all the scaling action remains in the electronic decades and the scaler and timer will stop automatically upon reaching the selected count. The register will also indicate the numeral 1 upon reaching 1K but the stop command will be taken from the left or 100's decade.

When the preset count switch is in the 5K, 10K, 50K or 100K positions the scaler and timer will be stopped by the register periodical contact closure upon reaching 100. For these preset count positions the decades section will act as a multiplier and perform as follows: assuming a selected preset count of 50K, in order for the total count to be numerically correct, multiply the register count of 100 by 500.

This is automatically accomplished by tapping the signal from the count of five on the left decade. When the electronic decade reaches 500 counts two things happen: the register advances by one count, and the decade scales are simultaneously reset to zero. The same holds throughout the remaining positions except CONT. In CONT. the carry signal from the left decade is directly connected to the register drive and the periodical contact in the register is left open.

The timer always turns on and off with the scaler provided that the timer switch is set to ON. If the timer times out before the scaler reaches a preset count the counting will also stop thus providing an overriding feature. The timer may be operated as either an interval timer or as a preset timer. When the former mode is selected the minutes knob must be rotated completely clockwise; the time must then be taken from the red numbers surrounding the dial and can be read in minutes and seconds.

Operating as a preset timer the time is set according to the black numbers and upon "timing out" (i.e., when timer reaches zero) the ON-OFF switch will close and stop the scaler. The timer should always be set with the timer switch to OFF; the switch should always be set to ON before initiating a counting run. The register must be reset before pushing the scaler start button which automatically resets the decades before turning on the operate gate.

There are two possible signal sources feeding into the scaler: an internal clock pulse operating at line frequency, and the detector signal from the amplifier-discriminator output. The front panel

TEST-COUNT switch allows selection of either one.

Amplifier-Discriminator

The amplifier allows the operator the option of a low input impedance current input, or a high impedance voltage input. The current input allows the detector to be connected with up to 25 feet of coaxial cable to the amplifier with no intermediary preamplifier. It also allows several detectors to be summed directly into one amplifier. A high voltage capacitor is included in the amplifier input to allow up to 6000 volts DC level to be present at the input. The voltage input of the amplifier is used in conventional fashion -- driven from the low output impedance of a preamplifier. The input circuit consists of capacitor coupling into a 10,000 ohm resistor.

The front panel GAIN varies the gain by factors of 10 in 3 steps: X1000, X100 and X10. The maximum gain is 1000 for the voltage input and 10 volts per microampere for the current input.

The amplifier output feeds directly into a discriminator (on the same printed circuit board) which is variable from 0 to 100% (9 volts) of the amplifier gain by means of the DISC. ADJ. Maximum input sensitivity of the instrument is one millivolt when the DISC. ADJ is set to the extreme counterclockwise position.

High Voltage

The high voltage may be applied to the detector by means

of H.V. OUT J4 when the preamplifier is being used with voltage input, or by CURRENT IN J5 when the detector is operated in the current mode. When the high voltage STANDBY-ON switch is set to the ON position the voltage indicated on the front panel meter and the 10-turn helidial (more precise setting) is present at the high voltage rear connectors. In STANDBY the primary center tap of the high voltage transformer is connected to ground rather than to a regulated DC voltage; the secondary is connected with zero volts to J4 and J5.

No high voltage is present at the fuse terminals because the supply is protected against short circuits by means of F2 1.5 A in series with the -18 volt regulator connected to the primary center tap. A safety interlock on the front of the chassis automatically sets the high voltage supply to STANDBY whenever the front panel is opened.

50 cps Operation Option and/or 220 Volt

The Model 146 General Purpose Scaler is normally supplied for operation with 115 volts 60 cps power mains. The 50 cps option must be specified before delivery. The transformer is of the constant voltage variety and needs to be replaced in 50 cps units; the motor in the electromechanical timer must also be replaced since it is a synchronous type.

In 50 cps units the "test" counts will register at the rate of 3000 per minute instead of the usual 3600 cpm. If 220 volt operation is chosen a different transformer and line fuse must be installed.

CHAPTER
3

GENERAL PURPOSE SCALER THEORY

General

All components necessary to perform the several types of counting -- scintillation, geiger and proportional gas, and high voltage methane counting -- are included in the Model 146 General Purpose Scaler. Figure 3.1, the overall general purpose scaler logic diagram, illustrates functional relationships.

High Voltage Supply

The supply is designed to provide a continuously adjustable stable output over a range from 600 to 6000 volts for use with geiger tubes, proportional counters, and scintillation detectors. A maximum output of 6000 volts is ample for use with the latest trends in low background counting techniques. The complete solid-state design of the high voltage supply increases

operational reliability in keeping with the latest trends in transistor circuit design. Basically, the supply is a DC-to-DC converter using a well-regulated variable primary voltage as a means for controlling the output of a converter transformer. The output of the converter transformer is rectified, filtered and applied to the rear connector. Output voltage is continuously adjustable by means of a direct reading 10-turn H.V. ADJUST control. Metered output as well as a calibrated dial is incorporated to insure output setting repetition within a range of 10 volts.

For ease of maintenance and service, the supply is mounted on two printed circuit boards, PC1 and PC2, which slide in from the front of the cabinet, each making contact with a 23-pin connector. A safety interlock is provided, disabling the supply whenever the front panel is lowered exposing any dangerous areas.

Board PC1 contains the circuits associated with the regulator; board PC2 houses the switching circuits, transformer, and rectifier. A separate screw mounted subassembly contains all the filter elements. At the rear deck or chassis the low voltage supply is mounted, and provides power to the boards through one terminal strip. Either printed circuit board may be independently removed while the unit is off.

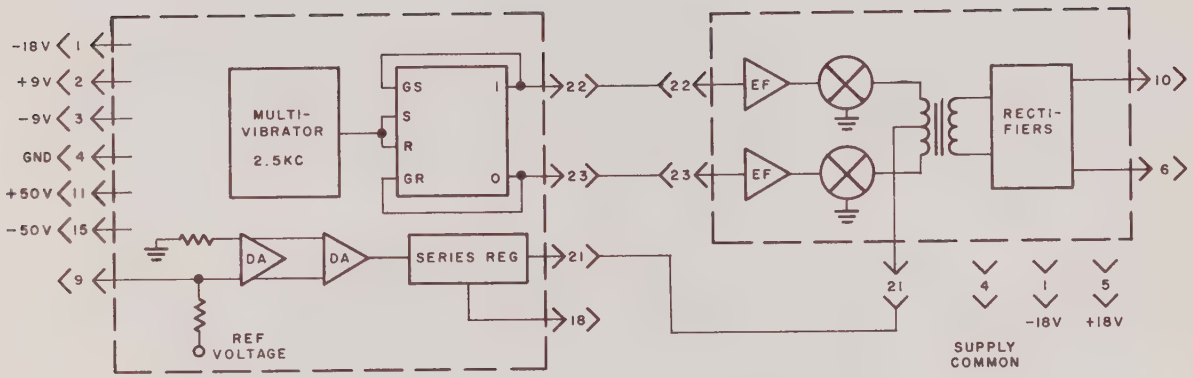
Referring to Figure 3.2, high voltage is generated by alternately shorting each transformer leg to ground through switching transistors. The absolute value of high voltage is determined by the amount of DC voltage applied to the center tap which, in turn, is determined by the setting of the front panel H.V. ADJUST control.

An astable multivibrator generates a 2.5 kc signal and is coupled to a flip-flop which functions to produce a symetrical drive to the transformer switches. In the process the drive frequency is reduced by a factor of two. A buffer stage, inserted between the flip-flop and the switches, provides isolation; it also provides a path for leakage current on alternate cycles where the switching transistors are cut off.

To obtain the desired load regulation and stability, a highly efficient regulating circuit is employed to control input voltage to the DC-to-DC converter. A sampling of the regulator output is compared with a zener reference voltage and the difference amplified and applied as a correction voltage to the converter transformer. The circuits may be discussed under five major loop elements -- sampling, reference, comparison, amplifier, and control.

The sampling element is the 10-turn H.V. ADJUST control mounted on the front panel. This control combines with a resistor in series with the reference supply to form an accurate voltage divider. The reference element consists of two zener breakdown diodes in series, constituting a stable 18 volt source. Two 9 volt diodes are used in preference to one 18 volt diode because of the smaller temperature coefficients obtainable with low voltage zeners.

The comparison element is a 6-terminal device containing two electrically identical, isolated transistors connected as a



HIGH VOLTAGE SUPPLY LOGIC DIAGRAM

Figure 3.2

difference amplifier. By having the junctions of the two collectors physically close to one another, a difference in parameters with temperature changes can be held to a minimum. The comparison amplifier, as the name implies, compares a portion of the regulator output with the reference and produces an output proportional to the difference voltage. Since the comparator is referenced to ground, the input appears as a virtual ground.

Any tendency for the regulator output voltage to vary other than in response to a change in the H.V. ADJUST control will occur as an error signal to the comparison element. The error is amplified and applied in proper phase to the regulator control element so as to correct for the change. When the H.V. ADJUST control setting is changed, for example, if the operator desired to select a different high voltage level, the circuits would force the regulator output to a voltage where the sampling and reference resistors maintained the proper divider ratio.

Comparator output, being insufficient in itself to properly correct for regulator output errors, is coupled to a DC amplifier before being applied to the control element. Total loop gain is sufficient to maintain the output within 0.03% of maximum output for changes in line voltage. Because the DC loop encloses the most critical parameters, the supply is quite stable over long and short periods of time.

The control element is a compound-connected series regulator which reacts to a change in base drive by making the necessary adjustment to the converter transformer primary. Any change in

high voltage output is thereby corrected.

The sampling and reference element along with the input differential stage contribute to the greatest changes that may be encountered with temperature. If all components changed in a combined worst direction, the high voltage output could possibly change by 0.05% per ^{o}C of maximum voltage. Due to the total number of components and their characteristics, this is statistically rare. Production units tested have a temperature coefficient of better than 0.01% per ^{o}C.

Since the feedback loop does not enclose the high voltage output, the load regulation is strictly a function of transformer internal resistance plus IR drops in the diode and coil This resistance is in the order of 100,000 ohms, small enough for the application of this type supply.

To decrease changes in high voltage output with AC line variations, a well-regulated low voltage supply is used as the source of input power. The power transformer provides 1% regulation of rectified output for a $\pm$10% change in line voltage. This coupled with additional regulation of critical voltages provides for an extremely stable supply for normal line voltage variations.

Amplifier

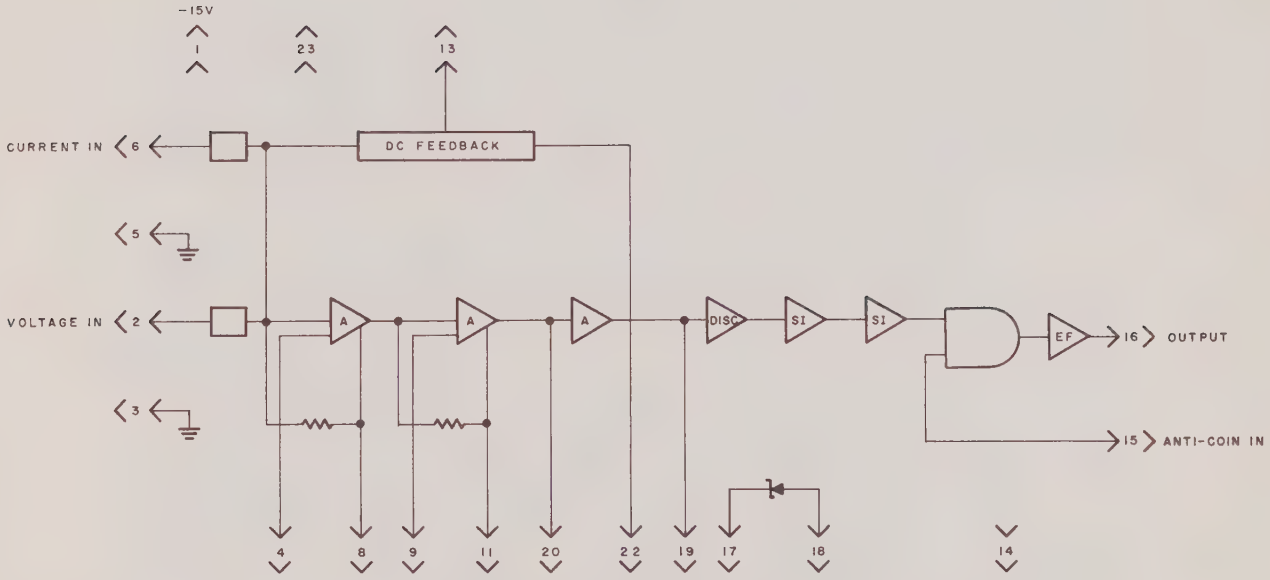
The amplifier, a non-overloading type pulse amplifier contained on board PC3, features exceptionally high and stable gain; it has both a current and voltage input for increased flexibility. As

shown in Figure 3.3 the amplifier consists of three direct coupled stages connected with an overall DC feedback network to maintain operating point stability. Direct coupling eliminates the need for coupling and bypass capacitors which could cause severe recovery problems when the amplifier is subjected to a wide dynamic range of signals.

Gain of each stage is controlled by negative feedback loops to stabilize it against power supply variations and parameter drifts due to temperature and aging. Amplifier gain is varied by changing the resistors in the feedback loops; to reduce total effective shunting capacity, feedback resistors are located near the GAIN switch.

The first stage consists of two doublet stages connected in a stabilized current gain configuration. Each doublet is comprised of a grounded emitter stage driving a grounded base stage in a complementary cascode arrangement. This configuration has proven advantages: high speed operation is enhanced due to the low impedance base-to-emitter junction, shunting the high collector impedance, and effectively eliminating the Miller multiplication of base-to-collector capacity. As a further advantage, many such stages may be directly coupled with no "creeping up" of operating points normally encountered in other direct-coupled stages, since each stage can operate with zero volts in and zero volts out.

The second doublet stage is very similar to the first with negative current feedback employed around the two doublets to establish the stage gain. Maximum current gain of the first stage is 32, when the gain switch is in position 1000; gain is 4 in position 100,



AMPLIFIER-DISCRIMINATOR LOGIC DIAGRAM

Figure 3.3

and 2.6 in position 10.

Since the negative feedback is to the input terminal of the stage, the input impedance of the stage is very low, being equal to the feedback resistor divided by the loop gain of the stage. Typically, input impedance is about 25 ohms. There are two inputs to the amplifier -- current input, pin 6, and voltage input, pin 2. The current input is used directly with a phototube with no preamplifier required; voltage input is used in conjunction with low output impedance preamplifiers.

Input current is amplified in the first stage and passed to the second stage through the grounded base of the second doublet transistor. The second stage is also a current gain stage identical in operation with the first stage. Stage two gain is varied from 32 to 26 and finally to 8 in the X 10 position.

The third stage consists of a doublet and a complementary emitter follower section connected as a current-to-voltage transfer stage. The amplified input current, coupled into the third stage, flows through the feedback resistance connected between pins 20 and 22. Feedback resistance consists of two 4.99 K resistors in series. The gain is 1 in the 1000 position and 1/2 for the remaining two positions.

The output of the amplifier, pin 16, is in the form of a voltage pulse. Dynamic output impedance of the complementary emitter follower is low, nominally less than 10 ohms. A major DC feedback network maintains desired operating points within the amplifier. The

maximum high frequency amplifier gain, equal to the DC gain if no DC feedback is employed, is 10 volts per microampere.

For example, a one microampere change in base current in the first stage would cause a 10 volt change at the output. The major feedback loop reduces this sensitivity at DC by a factor of 3000. A one microampere DC change in base current in the first stage changes the output by only 3 mv.

Maximum amplifier gain of the amplifier is 1000, referring to the voltage input, and 10 volts per microampere, referring to the current input. Gain may be reduced by factors of ten with the GAIN control to a minimum of 1/10 of the maximum.

Discriminator

The input discriminator is a differential amplifier which has zero gain until the threshold level chosen by the DISC. ADJ control is exceeded, whereupon the gain becomes quite high. Each time a pulse from the amplifier output exceeds the threshold level a positive pulse appears at the discriminator output. The negative going trailing edge of the pulse is differentiated and shaped by two shaping inverters, the second of which has a negative going pulse about 7 volts in amplitude and about 0.5 microsecond in width. This pulse enables the diode gate and a pulse appears at the output after passing through the complementary emitter follower used for capacity buffering. The condition remains true only if a negative or no signal is present at ANTI-COIN IN J3. If a ground level or positive voltage signal is present at J3 the diode gate is inhibited and no

signal will appear at the emitter follower output.

Ideally, the inhibit signal at J3 should be a flip-flop gating element at near ground or positive potential commencing with the leading edge of the pulse as it appears at the discriminator output and continuing with sufficient duration to overlap the pulse trailing edge.

The DISC. ADJ control establishes the reverse bias on the base-to-emitter junction. With no pulse present at the discriminator input, part of the discriminator is fully conducting, the other part turned off. When an input pulse exceeds the reverse bias set by the control the two sides change state in the following manner: the side that was off starts to conduct and takes part of the 3.5 ma current available away from the conducting side, the collector of which rises toward +18 volts. The positive rise is coupled back to the base of the side starting to conduct giving it a small amount of feedback so as to increase the discriminator gain and speed. As the discriminator passes from cutoff to full conduction, average gain from the input to the collector is about 500.

Scaler-Timer

The scaler consists of three electronic decades followed by a 4-digit register. The electronic section provides the scaler with a two pulse resolving time of 1 microsecond. The three decades occupy card positions PC4 through PC6. The card in position PC6 is a 1 mc decade board while the other two are 100 kc decade boards. The register, an electromechanical device, has a maximum speed of

25 impulses per second; it is driven by a delay flop located on the scaler control each time a pulse from a decade board (selectable by the preset count switch) is presented to the delay flop input. The delay flop provides a 20 millisecond duration pulse required by the register for proper operation.

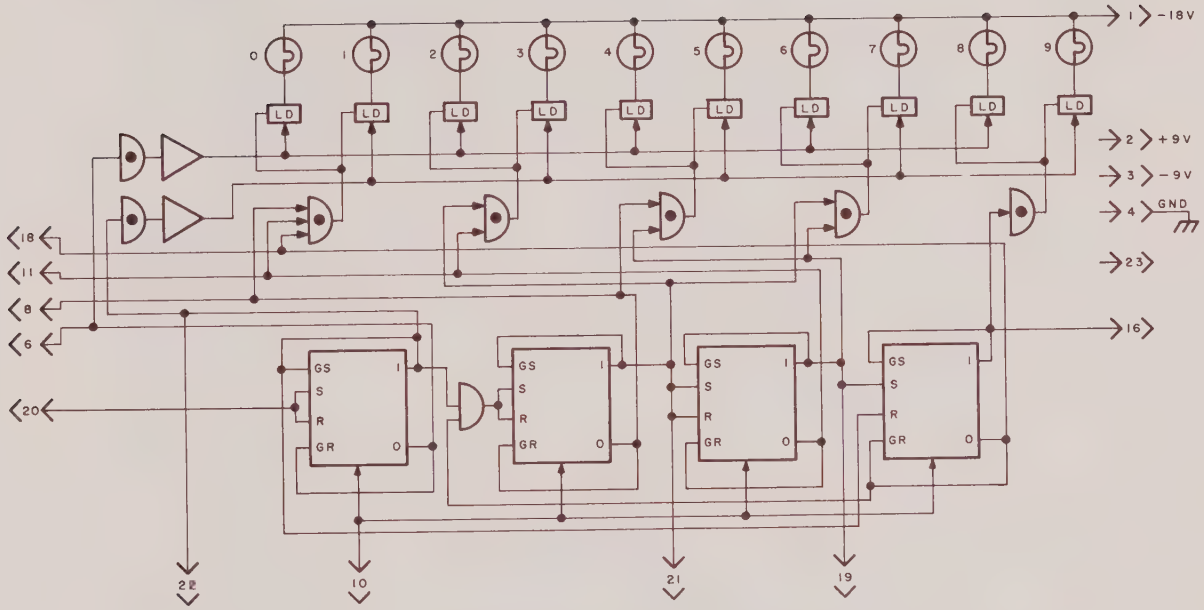
The register must be reset manually by the toggle handle located beneath the register digits; the scales are reset automatically by the scaler control whenever the start button is operated.

100 kc Decade Counter

The 100 kc decade counter shown in Figure 3.4 contains a four-stage binary-coded decimal counter, a BCD-to-decimal converter and 10 lamp drivers and lamp.

The counter consists of four flip-flops connected to give a 1-2-4-8 BCD code output. A BCD counter differs from a straight four-stage binary counter in that the counter recycles after 10 input pulses rather than 16 pulses. The counter starts in a reset condition of zero. As each input pulse comes in, the count advances from zero to nine in normal binary fashion. However, the tenth input pulse restores the count to zero rather than to ten. Since negative logic is employed, a flip-flop is in the ONE or set state when the ONE output is negative; it is in the ZERO or reset state when the ONE output is at ground. A flip-flop changes states when its input changes from a ONE to a ZERO state. The negative level is normally -6 volts ± 1; the zero outputs of the decade are -10 volts ± 2.

As Figure 3.5 shows, the relative timing of the four stages



100 kc AND 1 mc DECADE COUNTER LOGIC DIAGRAM

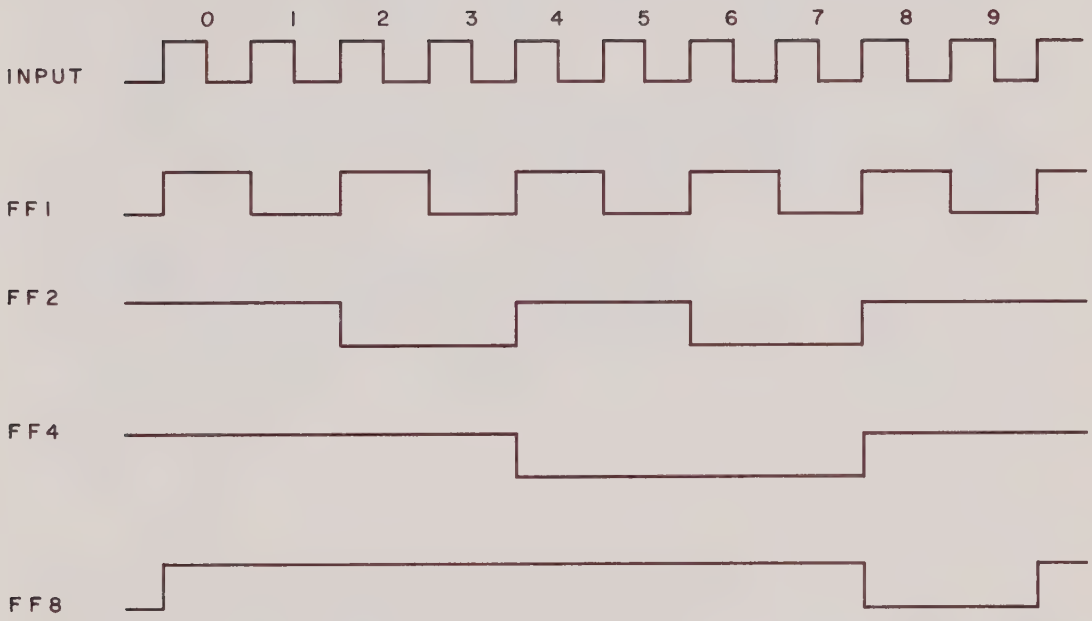
Figure 3.4

is identical to that of the first ten states of a four-stage binary counter. The BCD counter is implemented in the following manner: FF1 is complemented by the input signal coming in on pin 20. FF1 then drives the complement input of FF2 through the AND gate. $\overline{FF8}$ remains in the enabled condition until the eighth input pulse is received. FF2 changes states when the second, fourth, sixth, and eighth pulses arrive. Since $\overline{FF8}$ is in the inhibit condition from the time the eighth pulse is counted until the tenth pulse, FF1 being prevented from coupling when the tenth pulse arrives, FF2 is inhibited from changing states.

After the tenth pulse, FF2 and FF1 are in the reset condition. FF2 drives directly into the complement input of FF4. Since FF2 is reset from the ONE state to the ZERO state with the fourth and eighth pulses, FF4 is set with the fourth pulse and reset with the eighth pulse. FF4 drives the set input of FF8. When FF4 goes positive on the eighth pulse, FF8 is driven to the set state. FF8 is returned to the reset state by FF1 when the tenth pulse arrives. Therefore, after the tenth pulse, all four flip-flops are in the reset condition, ready to start the count of ten again. The output of FF8 is taken out through pin 16 to connect to the input of the next decade.

The direct reset input is brought in on pin 10. When a positive pulse appears at pin 10, all flip-flops are forced to a reset condition.

Incandescent lamps indicate the state of the counter at any instant. Lamp DS101 lights up numeral 0, DS102 lights up numeral 1, and so forth. Emitters of the even numeral drivers are connected



BCD COUNTER TIMING DIAGRAM

Figure 3.5

together; emitters of the odd numeral drivers are also connected together but separately from the even numerals.

Multiple use is made of the decoding done for the lamps. The output of certain drivers is brought to the PRESET COUNT switch, used for presetting a count on the scaler or choosing a multiplying factor for the register.

Depending on the external switch connection, the resulting signal may be used to stop the scaler, reset and start the scaler while simultaneously pulsing the register, or simply to pulse the register.

1 mc Decade Counter

A higher speed flip-flop is used in the 1 mc decade counter. No outputs other than the carry signal to the next decade are taken from it. Figure 3.4 shows a detailed logic diagram.

Timer

The electromechanical timer is a standard commerical X-ray timer which can be used in either the preset or interval timer mode. Power to the timer is turned on and off by means of a relay that is driven by the scaler control board. However, the timer will not run unless the pointer is moved off of zero and the timer switch is set to ON. The timer switch opens a set of contacts connected to the scaler control stop line, and energizes a clutch solenoid in the timer. When time runs out (reaches zero)

the timer switch is mechanically tripped off; the resulting switch closure in the scaler control stop line provides a stop signal to the scaler. Then the decade scales are gated off with the timer drive relay.

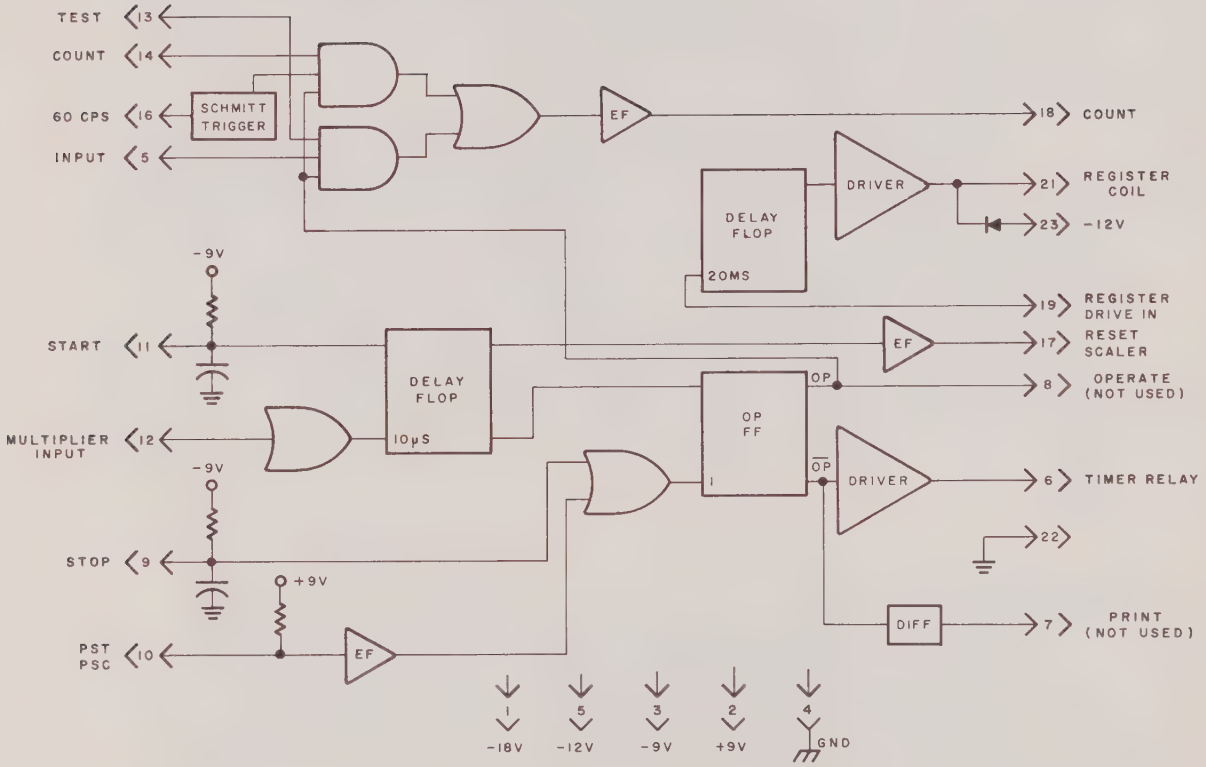
When using the timer as an interval time device, turn the time selector knob completely clockwise at the start of each counting run and read the elapsed time in minutes and in seconds with only the red timer numerals. Select a preset time by setting the time selector knob on the desired time interval and guiding with the black numerals. In either case, when the timer times out or reaches zero time, the switch will be tripped off and counting will stop.

Scaler Control

The scaler control board, Figure 3.6, contains circuits for starting and stopping the scaler and timer, reset circuits for the decade scales, the 60 test signal generator and the register drive flip-flop.

The output from the amplifier-discriminator feeds into pin 15, passes through some gating and comes out at pin 18 to drive the first scaler decade. The gating of the signal is under control of the OP flip-flop which also controls the timer relay drive circuit.

When the TEST-COUNT switch is set to COUNT, pin 14 is grounded. This inhibits the test signal gate so that only the



SCALER CONTROL LOGIC DIAGRAM

Figure 3.6

input signal can pass through to the output. When the switch is set to TEST the converse is true: pin 13 is grounded so that the input signal gate is inhibited, and the test signal gate enabled.

The test signal operator, connected to pin 16, is a Schmitt trigger circuit driven by an 18 volt AC signal operating at line frequency.

The start function is accomplished by pressing the START button which develops a pulse at pin 11 to trigger the delay flop; it then generates a positive going 10 microsecond pulse from its zero side and a negative going pulse from its one side. The leading edge of the positive pulse is differentiated and passed through an emitter follower to pin 17 to reset only the electronic decades.

The trailing edge of the 10 microsecond negative pulse from the delay flop sets the OP flip-flop. The signal goes negative, conditions the count gates and allows either the test signal or the input signal to drive the count input of the scaler.

The positive going side of the OP flip-flop is connected to the timer drive relay circuit. When the OP flip-flop is in the reset condition, the inverter transistor preceding the relay drive transistor has its base at a negative potential and is nonconducting because the OP flip-flop transistor, to which it has its base connected, is turned off. Under this condition the timer relay drive transistor is also shut off and the timer is off. When the OP flip-flop is set, the base of the inverter goes positive to saturate it; since its collector goes negative the relay driver transistor also

saturates. This causes the relay to be energized which turns the timer on.

In any mode of operation the counting cycle may be stopped in three ways: manually, preset time or preset count. Each of the methods is overriding, stopping the count if it occurs before any of the others.

When the STOP button is pressed a positive pulse appears at pin 9 causing the OP flip-flop to reset; counting then stops and the timer relay removes power from the timer.

For preset time stop, when the timer reaches zero or times out, the switch closes to produce a positive pulse at pin 9 duplicating the above results.

In the preset count mode there are two methods employed to stop the scaler-timer depending on the preset count switch position. If the preset count is 1000 or less the positive pulse from the decade output selected appears at pin 10 of the scaler control board, passes through an emitter follower, and resets the OP flip-flop. For all remaining preset count positions the same procedure described for the preset time switch closure occurs except that the switch closure takes place in the register upon reaching the register count of 100.

The register drive circuit is simply a 20 millisecond delay flop preceded by an emitter follower and followed by the register drive transistor. The positive pulse from a decade output is applied to pin 19. The delay flop is triggered to remain in the on state for

20 milliseconds. The base of the relay drive transistor goes negative and saturates for the duration of the on period to drive the relay. When the delay flop returns to the off state the transistor, which determines the relay transistor drive base bias, turns off so that its emitter is at a positive potential. It is this potential which cuts off the relay drive transistor.

When the preset count switch is set on the 5K, 10K or 50K positions the same signal, which triggers the register drive delay flop, also connects to pin 12, the multiplier input. This is a reset-start signal to trigger the 10 microsecond delay flop. It resets the decade scales to zero so as to produce the correct multiplying factor for the register.

Register

The electromechanical register, which follows the last decade scale, has a maximum operating speed of 25 impulses per second. A front panel toggle arm provides for manual reset and an internal, periodical switch closure on the count of 100 is used to generate a scaler stop signal for some of the preset count positions.

Since the maximum counting rate is 25 ips or 1500 cpm, the maximum allowable continuous counting rate when the PRESET COUNT switch is set to the 5K position is 65,000 cpm, 150,000 cpm in the 10K position, and 650,000 cpm in the 50K position. For the remaining PRESET COUNT switch positions the maximum counting rate is 1.5 million cpm.

GENERAL PURPOSE SCALER THEORY

System Supply

The system supply as shown in Figure 3.1 is designed to provide reliable general purpose scaler operation over a wide range of line conditions. Using a constant voltage ferroresonant transformer, the power supply offers fast line regulation, short circuit protection, automatic current limiting and increased circuit reliability. This type of system supply need only be followed by additional regulations where most critical circuit operation is required.

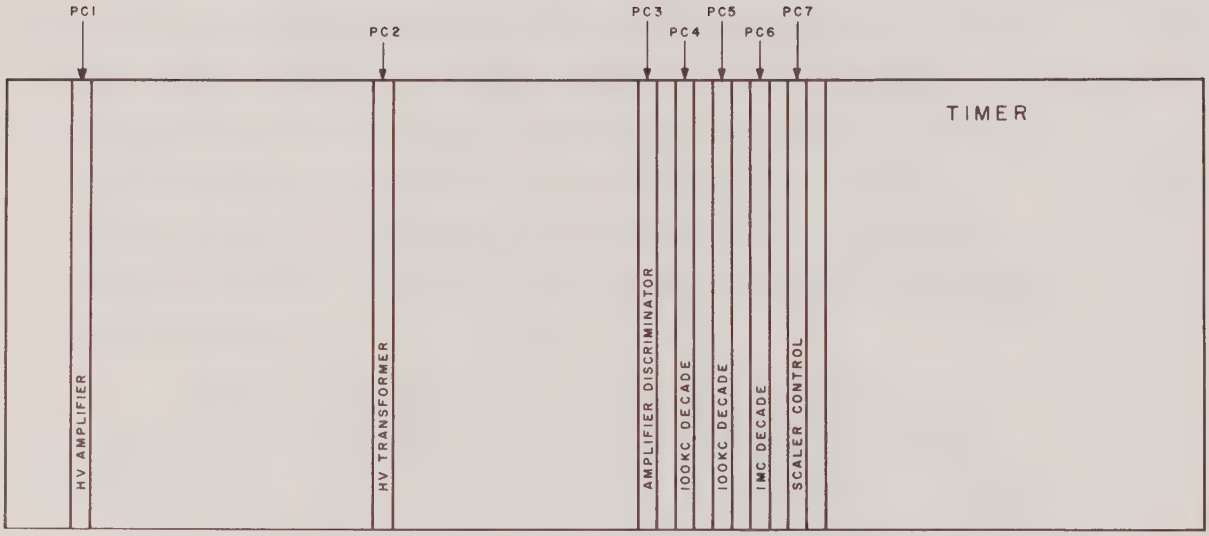
The basic supply consists of a full wave capacitor input circuit. The transformer, a constant voltage device, provides for 1% regulation of the raw supply over all normal line variations. For those circuits requiring a higher degree of regulation and isolation, additional regulators have been incorporated to provide -15, -9, +9, and +18 volts. These series regulators are emitter followers whose output voltage is maintained substantially constant. A divider provides a 9 volt signal referenced from the line used as the test pulse input to the scaler control. A separate winding provides an additional regulated voltage rectified and filtered to produce -50 and +50 volt supplies.

CHAPTER
4

TROUBLESHOOTING

The general purpose scaler is constructed so trouble-shooting can be performed without removing the card cage from its cabinet or the cabinet from the rack, if rack mounted. Card locations are shown in Figure 4.1.

All printed circuit boards are accessible from the front merely by lowering the hinged front panel. The boards may then be easily extracted by hand. Extender boards which plug into any of the connectors are available; the extender boards have a 23-pin female connector mounted on the edge closest to the front panel to accommodate any of the printed circuit boards, allowing work on the board while it is still connected.



PRINTED CIRCUIT BOARDS, FRONT VIEW

Figure 4.1

Scaler-timer troubleshooting is easily performed since 2 of the 3 boards used, the 100 kc decade boards, are identical and may be interchanged at random. One may troubleshoot by substitution, then, in the area of the 100 kc decade counter. A TEST mode is included in the scaler control TEST mode for checking purposes and can be a valuable aid in troubleshooting. In TEST the 60 cps time signal is inserted as the input to the scaler control, allowing it to be checked out with a steady signal applied.

If problems appear in the timer, trace in the scaler control and relay to isolate and repair; if problems appear in either the register or timer, trace and isolate within these components to repair.

Refer to Chapter 3 and the logic diagrams included in it to isolate and clarify any technical problems. If trouble in the general purpose scaler cannot be located and repaired, contact the nearest Baird Atomic office.

CHAPTER

5

PARTS LIST

All Model 146 General Purpose Scaler components are fully identified in order to make possible procurement of replacements. Reference designations appear schematically on the general purpose scaler logic diagram Figure 3.1, and identify electrical/electronic component parts referenced in drawings or the text of this manual; mechanical parts which are not likely to require replacement during normal general purpose scaler service life are not assigned reference designations or included in this parts list. For easy location all items given a reference designation in the parts list are arranged in alpha-numerical order. Exact general purpose scaler panel stamping, when it exists, is reproduced as part of the name of component and description column. Those few items listed without an assigned reference designation are included last in alphabetical order.

MODEL 146 GENERAL PURPOSE SCALER PARTS LIST

REF. DESIG.	NAME OF COMPONENT AND DESCRIPTION	PART NUMBER
C101 and C106	Capacitor, mylar, 0.0001 uf, 10 kv	00476
C102	Capacitor, electrolytic, 25 uf, 25 volts	00532
C103 and C104	Capacitor, 0.05 uf, 8 kv	30801
C105	Capacitor, mylar, 0.1 uf, 400 volts	00583
C107 and C108	Capacitor, 200 uf, 20 volts	03118
C109	Capacitor, 0.001 uf	00015
F1 and F2	Fuse, 1.5 amp, SLO-BLO	08627
J1 and J3	BNC connector	00756
J2	7-pin connector	00742
J4 and J5	HV connector	00716
K1	Relay, 12 volts, DPDT	32252
L1	Toroid choke, 5 henries	30327
M101	Meter	30916
PC1	6 kv amplifier board	30513
PC2	6 kv transformer board	30505
PC3	Amplifier-discriminator board	32170
PC4 and PC5	100 kc decade board (less switch)	30839
PC6	1 mc decade board (less switch)	30838
PC7	Scaler control board	32187

MODEL 146 GENERAL PURPOSE SCALER PARTS LIST (Cont.)

REF. DESIG.	NAME OF COMPONENT AND DESCRIPTION	PART NUMBER
R101	Resistor, 220 k, 1/2 watt, ±5%	00303
R102	DISC. ADJ, potentiometer, 1 k, 2 watt, ±10%	00593
R103	Resistor, 13 k, 1/2 watt, ±5%	00364
R104 and R107	Resistor, 90.0 ohms, 1/4 watt, ±1%	30265
R105	Resistor, 95.3 ohms, 1/4 watt, ±%	30269
R106	Resistor, 1.8 k, 1/4 watt, ±1%	32250
R108	Resistor, 115 ohms, 1/4 watt, ±1%	32251
R109	Resistor, 412 ohms, 1/4 watt, ±1%	30267
R110 and R111	Resistor, 4.99 k, 1/4 watt, ±1%	30268
R112	H.V. ADJUST, potentiometer, 20 k, 10-turn	30945
R113	Resistor, 20 ohms, 1/2 watt, ±5%	00026
R114 and R123	Resistor, 100 ohms, 1/2 watt,	00058
R115	Resistor, 20 meg, 2 watts, ±5%	30874
R116 through R121	Resistor, 3.6 meg, 2 watts, ±5%	32131

MODEL 146 GENERAL PURPOSE SCALER PARTS LIST (Cont.)

REF. DESIG.	NAME OF COMPONENT AND DESCRIPTION	PART NUMBER
R122	Resistor, 10 k, 1 watt, ±5%	00192
R124	Resistor, 500 ohms, 1/2 watt, ±5%	01331
R125	Resistor, 510 ohms, 1/2 watt, ±5%	00092
R126	Resistor, 10 k, 1/2 watt, ±5%	00368
S1	PRESET COUNT, rotary switch, 4-pole, 9-position	32249
S2	GAIN, rotary switch, 3-pole, 3-position	32062
S3	TEST-COUNT, toggle switch, SPST	30431
S4	START, pushbutton switch (black)	01255
S5	STOP, pushbutton switch (red)	03124
S6	ON-POWER-OFF, toggle switch, SPST	30431
S7	STANDBY-ON, toggle switch, SPST	30431
S8	Interlock switch (behind front panel)	30320
	Cabinet (including stand)	31471
	Connector, 23-pin	30289
	Dial, 15-turn	32248
	Display window	32078

MODEL 146 GENERAL PURPOSE SCALER PARTS LIST (Cont.)

REF. DESIG.	NAME OF COMPONENT AND DESCRIPTION	PART NUMBER
12V DC 600mA	Instruction manual	32258
	Knob, round skirted	30393
	Knob, pointer, gray	30851
TCEZ4EtV100.25 2507	Register, 4 digit	32231
	System supply	32247
	Timer	00408
	Extender board, 23-pin	30824

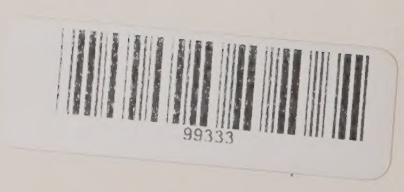
28.60

49.90

APPENDIX

MODEL 146 GENERAL PURPOSE SCALER SCHEMATIC DRAWINGS

DWG. NO.	NAME
C-30496	6 kv Transformer Board
C-30504	6 kv Amplifier Board
D-30842	1 mc Decade (less switch)
D-30843	100 kc Decade (less switch)
D-30971	Amplifier-Discriminator
D-30978	Scaler Control
C-30998	System Supply
E-32031	Model 146 General Purpose Scaler Logic Diagram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